INTER-DEPARTMENTAL REPORT

BRISTOL BAY DATA REPORT NO. 89

INSHORE ABUNDANCE OF PACIFIC HERRING IN THE BERING SEA DURING THE 1980 SPAWNING SEASON

by

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INTRODUCTION

This report describes methods used for assessment of the abundance of herring in the Bering Sea during the 1980 domestic inshore roe fishery and results of post-season analysis. Basic methods of data collection used in 1980 were identical to those used in 1978 and 1979 (Barton and Steinhoff 1980). Repeated aerial surveys were conducted over the spawning grounds to determine number, size, and location of fish schools. Occurrence and extent of spawn or milt were also noted, as well as fishing effort and visibility factors affecting the quality of surveys. Test fishing with variable mesh gillnets was conducted on the Togiak, Security Cove, Cape Romanzof and Norton Sound (Cape Denbigh) fishing grounds (Figure 1) to collect herring samples for age, weight, sex and maturity analysis and to determine relative abundance of other schooling fishes (capelin, smelt, sand lance and cod) which might be mistaken for herring by aerial observers. In Togiak District, commercial purse seine vessels and crews were contracted to capture herrring schools of known surface area to enlarge an existing data base on the relationship between school surface area and biomass. Finally, additional information pertinent to stock assessment was obtained through monitoring magnitude, timing, location and composition of commercial harvests of both herring and herring spawn-on-kelp. The Department of Fish and Game operated field camps and a large support vessel within the Togiak, Security Cove, Cape Romanzof and Norton Sound Districts.

TOGIAK DISTRICT (BRISTOL BAY)

Aerial Survey

During the 1980 season 22 survey flights in the Togiak District were made between April 15 and June 2. Two biologists experienced in aerial survey techniques participated in most of these flights, frequently in the same aircraft at the same time. Suitability of survey conditions (visibility of fish schools) was rated on a five point scale from excellent to unacceptable for each flight and index area. Visibility data for surveys during the period 1978-1980 indicated that 1980 was similar to past years:

	1978	1979	1980
Excellent	4%	0%	1%
Good	19%	25%	29%
Fair	25%	25%	28%
Poor	29%	26%	28%
Unacceptable	23%	24%	14%

Water turbidity was the primary problem in 1980, occurring to some degree on 17 of the 22 flights. Other factors which reduced the effectiveness of aerial surveys were rough seas, rain or snow squalls, low ceilings, wind, fog, poor light and heavy spotter plane traffic. Examination of survey rating data, maps and notes indicated that visibility of fish schools was as good as or better than that of the previous two years. Survey conditions were rated poor or unaccepatble in all index areas on May 11 and 13 resulting from intense storm activity on May 9, 10, and 12. Conditions improved to fair in four of five index areas flown on May 14 and to fair or good in four of six areas surveyed on May 19. It is unlikely that large numbers of herring schools were present in the Togiak District during this time but not observed.

Test Fishing

Eighty-two sets were made using variable mesh gillnets in the Nushagak, Kulukak, Nunavachak and Togiak Bay portions of the Togiak District (Figure 2). Duration of sets varied from 10 minutes to 18 hours depending upon the time necessary to capture a sample of fish. Test fishing began May 3 and continued through May 29, nearly 3 weeks after the commercial fishery was closed.

A total of 6,447 fishes were collected of which 83% were Pacific herring. However, herring composed 96% of the schooling, pelagic fishes which were likely to be spotted by aerial observers. Capelin, also abundant at times in Togiak District, were not caught in the test nets until May 19 and then only in very low numbers. Analysis of age, weight, sex and maturity data from test fishing and commercial catch sampling has been done by McBride and Whitmore (1981).

Relative Abundance and Timing

To facilitate comparisons between years, and between dates and areas within years, aerial survey observations of fish school numbers and sizes in Togiak District were converted to relative abundance indices (RAI's) following the method of Barton and Steinhoff (1980). Each observed school was converted to an equivalent number of small fish schools of standard area (50 m^2 = 1 standard school = 1 RAI unit). RAI data by index area and date for 1980, 1979 and 1978 are presented in Tables 1, 2 and 3, respectively.

No fish schools were observed at the time of the scheduled fishery opening on April 15, and the first commercial herring delivery was not made until April 25. Fish schools were observed in the Nushagak, Kulukak and Nunavachak index areas on April 28 and on all subsequent flights except those on May 11 and 13. Test net and commercial catches support the assumption that the vast majority of fish schools observed were composed of herring.

Herring reached peak abundance in 1980 during the period May 3-6. On May 8, with good to excellent visibility, only about 40% of the peak abundance was observed. Also, spawn deposition at that time, based upon surveys and spawn-on-kelp harvest montoring, was light and limited in extent. These factors all contributed to the closure of the herring fishery on May 10. Although the storm of May 9-12 reduced survey effectiveness from May 9-13, later surveys under improved conditions indicated a nearly constant, low level of herring abundance.

Compared to 1978 and 1979, the 1980 herring run initailly developed more rapidly, but relative abundance at the peak fell far below either of those years in nearly all index areas (Figure 3). The highest combined RAI for any single date in 1980 was about 10% of that in 1979 and about 30% of that in 1978. The 1980 run was largely over by May 10 which was the date of peak abundance in 1979 and the very beginning of the run in 1978.

Herring spawn deposition in the Togiak area was estimated during aerial surveys in 1978, 1979 and 1980 (Table 4). Observers mapped areas of milt (i.e. number of spawnings) and then calculated the corresponding length of shoreline covered by the milt (i.e. miles of spawn).

Due to difficulties encountered in quantitatively assessing herring spawn deposition from aerial observations, these results can serve only as general comparisons. Some of the potential sources of error in aerial observations include miltiple counts of the same herring spawn, multiple spawns within the same area, undocumented offshore spawnings, and variable survey conditions. Also, and probably most crucial, very little ground work was conducted to measure extent or quality (number of layers) of deposited spawn.

The 41.2 miles of spawn in 1978 and 21.9 miles of spawn in 1979 represented medium to heavy spawn depositions. Spawn deposition was studied at five locations in Metervik Bay in 1978 and ranged from 1 to 8 egg layers. Ground surveys were conducted from Kulukak Bay to Right Hand Point in 1979 and spawn deposition ranged from 1 to 6 egg layers. Commercially harvested herring spawn-on-kelp in 1979 was generally classified as fair to good (3 to 5 egg layers).

The 23.1 miles of spawn in 1980 was considered to represent very light spawn deposition. Ground surveys conductd in Togiak Bay on May 6 documented 1 to 2 egg layers, primarily on rockweed kelp. Processors evaluated commercial spawn-on-kelp quality as fair to poor (1 to 3 egg layers). The May 9 - 12 storm may have destroyed a substantial amount of existing herring spawn (9.3 miles or 40% of total).

Biomass Estimation

Contracted purse seiners provided tonnage data for six additional schools of estimated surface area in the Togiak District in 1980. Thus, there are 9 data

pairs from the 1978-80 period (Table 5). Barton and Steinhoff (1980) assumed that herring school density (tonnage per unit surface area) increased with water depth (e.g. a school of 50 m^2 surface area in 20 meters of water might have a biomass twice as great as the same sized school in 10 meters of water) and calculated herring biomass in the various index areas on the basis of estimated water depths. However, school density estimates to date do not support or refute their assumption and bathymetry information is incomplete. Therefore, a simple arithmetic average of the 9 data points (3.4 mt/RAI) was chosen for estimation of herring biomass in 1980. Relative abundance indices from aerial surveys on May 6, 19 and 20 were used as the basis of calculations. Herring present on May 6 were about 93% 6,7 and 8 year old fish, whereas those present on May 19 and 20 were about 60% 3 and 4 year old fish. It was necessary to utilize RAI's from both May 19 and May 20 to obtain good surveys of all index areas. When two biologists flew surveys together, the observations of the one who mapped the maximum number of schools were used (Table 6).

In 1980, the combined RAI for all index areas in the Togiak District on May 6, 19 and 20 was 15,249 mt (Table 6). Applying the 3.4 mt/RAI conversion factor yields an estimated biomass of pelagic schooling fishes of 51,846 mt. Based on test fishing results 4% (2,074 mt) were fishes other than herring. Therefore, the estimated herring biomass was 49,772 mt. Commercial fishery removals and wastage (12,508 mt) prior to the May 6 peak aerial survey were added to survey results to yield a total estimated herring biomass for the Togiak District of 62,280 mt in 1980. This estimate may be conservative since multiple waves of spawning herring could arrive and depart throughout the season with only a portion being present during peak aerial survey periods.

If only 1980 biomass conversion data from Table 5 were applied to school surface areas the estimated biomass would be reduced by 50%. A preliminary estimate using 1978 and 1979 biomass conversion factors produced a biomass estimate for Togiak District herring in 1980 of 69,250 to 146,052 mt. However, a biomass of 146,052 mt would still be 19% below the lowest estimate for 1978 (172,600 mt) and 35% below the lowest estimate for 1979 (216,800 mt).

DISTRICTS NORTH OF BRISTOL BAY

Estimation of herring biomass in districts north of Bristol Bay was more difficult due to the greater frequency of poor weather and turbid water conditions and the fewer surveys flown during the season. Also, biomass conversion factors used were taken from observations in Togiak District and may not be appropriate for these districts. However, RAI data is believed to depict the relative abundance of these northern stocks from year to year (Table 10).

Biomass estimates were made for Security Cove and Norton Sound in 1980 using techniques previously described for Togiak. Unacceptable survey conditions precluded assessment of herring abundance in Goodnews Bay, Nelson Island and Cape Romanzof areas during 1980. Biomass estimates for these areas were based largely on 1978-79 data.

Several unsuccessful attempts were made to survey herring stocks north of Norton Sound. However, information from test fishing and subsistence catches during fall, winter and early spring indicates that these stocks remain in

inshore waters year-round and do not join other Bering Sea herring stocks on wintering grounds north of the Pribilof Islands.

Security Cove

Thirteen aerial surveys were flown in this District from May 2 through June 7 during the 1980 season, about triple the effort of the previous year. Twelve surveys were made under fair to excellent conditions. Fish schools were observed on all flights, however, peak relative abundance (407 RAI units) on May 22 was only 14% of the peak abundance of the previous year (Table 7). Only one light cloud of milt was seen in Security Cove proper on May 13, although additional spawning was noted west of Security Cove on June 7.

Test fishing with variable mesh gillnets was conducted from May 12 through June 3. A total of 33 sets captured 5303 pelagic schooling fishes of which only 23% were herring. This was not thought to be representative of the entire District since the limited area in which test fishing ocurred had high numbers of capelin. Therefore, in calculating 1980 herring biomass, 75% of the total fish school area and biomass was assumed to have been herring, the same proportion used in 1978.

In estimating 1980 herring biomass for Security Cove, abundance indices (RAI's) for May 18 and 26 were summed resulting in an RAI of 435 (Tables 7 and 10). Herring from test fish samples prior to May 18 were about 85% age 6 or older, while herring taken after May 25 were about 77% age 3 or 4. Applying a biomass conversion of 3.4 mt/RAI resulted in a fish biomass of 1479 mt. Assuming that 75% of that biomass was herring and adding commercial fishery removals prior to May 18 (34) mt, the estimated biomass of herring in Security Cove in 1980 was 1143 mt.

Goodnews Bay

Aerial surveys in this District in 1980 were severely restricted by weather and turbidity. One survey on May 8 under fair to poor conditions resulted in a relative abundance index of 240. A second survey on May 16 under excellent conditions indicated no fish schools were present. The May 8 survey resulted in a minimum biomass estimate of schooling fishes of 816 mt. However, it was assumed that herring populations in Goodnews Bay fluctuated in a similar manner to those of adjacent Security Cove, which experienced an 85% decrease from 1979 to 1980. Following that assumption, 15% of the midpoint of the 1979 biomass range (7,550 mt) was used as the 1980 biomass estimate of 1,132 mt.

Nelson Island

Aerial survey conditions were unacceptable for this area during 1980. Subsistence catch data indicated that herring abundance was similar to or slightly greater than than of 1979. The best estimate of 1980 herring biomass was about 5,400 mt, the low end of the range of estimated biomass for 1979 (5,421 - 8,900 mt).

Cape Romanzof

In this District, as in Goodnews Bay District, aerial survey data were inadequate for biomass estimation. Test fishing and spawn deposition studies indicated that 1980 herring abundance was at least equal to 1979. The best estimate of biomass was 2,700 mt, the low end of the biomass range of 2,700 to 4,400 mt indicated for 1978 and 1979.

Norton Sound

Aerial surveys were flown over portions of this extended coastline on 12 days between May 8 to June 26, 1980. Although fish schools were observed on all surveys, visibility was frequently reduced due to poor weather and turbid water. Survey conditions in 1980 were worse than those encountered in either 1978 or 1979:

	1978	1979	1980
Excellent	35%	24%	19%
Good	25%	40%	11%
Fair	25%	16%	22%
Poor	15%	16%	14%
Unacceptable	0%	4%	33%

Test fishing with variable mesh gillnets was conducted near Cape Denbigh from May 23 through June 9. Twenty-eight sets captured 4,275 pelagic schooling fishes, of which 99% were herring. Therefore, the biomass of other schooling fishes was ignored when calculating herring biomass..

In 1980, peak abundance of fish schools in Norton Sound was reached at the end of May or early June in most index areas (Table 8). In most index areas 1980 peak indices equalled or exceeded those of 1979 (Table 9). The 1980 herring biomass estimate for Norton Sound, calculated as the product of the combined index area RAI's of 2,242 and the surface area biomass conversion factor of 3.4 mt/RAI, was 7,623 mt.

SUMMARY

The abundance of Pacific herring declined significantly in inshore waters of the Bering Sea south of the Yukon River (Togiak, Security Cove, Goodnews Bay Districts) in 1980 as compared to abundance observed in 1978 and 1979 (Table 10). Spawning deposition in Togiak District was also reduced. Spawning herring abundance in Norton Sound appears to have increased, but not enough to offset the reduction in populations further south.

Spawning herring abundance data from Nelson Island and Cape Romanzof were incomplete, but appeared to be of the same order of magnitude as was observed in 1978 and 1979. The 1980 estimate of spawning herring biomass in inshore waters of the Bering Sea was 82,900 mt (Table 11).

LITERATURE CITED

Barton, L.H. and D.L. Steinhoff. 1980. Assessment of spawning herring stocks at selected coastal areas in the eastern Bering Sea. Alaska Department of Fish and Game Informational Leaflet No. 187. 60 p.

McBride, D. and C. Whitmore. 1981. Age composition of Pacific herring, Clupea harengus pallasi (Valenciennes), in the Togiak District of Bristol Bay during the 1979 and 1980 spawning season. Alaska Department of Fish and Game Informational Leaflet No. 191. 27 p.

Table 1. Relative abundance of fish schools in the Togiak District of Bristol Bay in 1980 based on aerial survey data. Numbers represent counts of schools standardized by surface area.

	Nushagak	Kulukak	Nunavachak	Ungalikthluk	Togiak	Matogak	Total
4/15	0	0	0	0	0		
/////							
4/28	259	101	7	0	0		367
29							
30	122	2,105	0	0	40		2,267
5/01							
2	60	142	6	71	45		324
3	336	2,915	43	318	8,873		12,485
4							
5	0	0	0	913	149		1,062
6	1,175	4,599	19	346	4,730	166	11,147
7							
8	788	1,238	0	310	2,332	389	4,668
9							
10							
11		0	0	0	0		0
12							
13	0	0	0	0	0		0
14	0	30	59	12	0		101
15	23	0	487	864	+		1,374
16	0	175	96	7	0	0	278
17							
18							
19	0	20	203	147	1,387	0	1,757
20	512	835	178	1	0		1,526
21							
22	0	633	27	277	5	0	942
23							
24							
25							
26							
27	0	429	472	106	0		1,007
28							
29	25	182	553	75	0		835
30							
31	236	123	32				391
6/01							
2							
/////							
7	0	378	218	36	0	534	1,203

Table 2. Relative abundance of fish schools in the Togiak District of Bristol Bay in 1979 based on aerial survey data. Numbers represent counts of schools standardized by surface area.

Date	Nushagak	Kulukak	Nunavachak	Ungalikthluk	Togiak	Matogak	Total
4/30		0	42	752			794
5/01							
02	0	0	900	1,004	71		1,975
03	61	0	5	317			383
04	17,355	563	71	280	1,460		19,729
05	18,724	29,918	326	159	486		49,613
06							
07	981	24,389	91	58	65,602	932	92,053
08							
09	0	0	46	743			789
10	76,783	12,312	21	+	46,956		136,072
11							
12	0	0	79	+	13,066	+	13,145
13							
14	340	+	31	29	2,522	699	3,621
15							
16	0	0	6	0	474		480
17	337	2	62	0	+	0	401
18							
19							
20							
21	0	0	0	0			
22							
23							
24	0	6	10	56	2,768	0	2,840
25							
26	0	0	34	7	2,767		2,808

Table 3. Relative abundance of fish schools in the Togiak District of Bristol Bay in 1978 based on aerial survey data. Numbers represent counts of schools standardized by surface area.

Date	Nushagak	Kulukak	Nunavachak	Ungalikthluk	Togiak	Matogak	Total
4/30							
5/01		805	0	0			805
02							
03	0	87	0	0			87
04							
05	0	2,957	0	0	0	0	2,957
06							
07							
08	0	923	0	10			933
09	0	0					
10							
11	410+	3,571	141	25	4,515	785	9,447
12	0	41	19	63	5,976		6,099
13	6,323	15,130	14,404	893	3,499	2,801	43,050
14	0	2,218	1,231	981			4,430
15							
16							
17	+	+	+	88			88
18	5,453	14,935	2,736	111	41,436	145	64,816
19		6,631	5,089	17			11,719
20							
21	+	198	42	91	0		331
22	0	150					150
23							
24	+	0	+	0			
25	161	45	509	87	116	+	918
26	0	421	377	+	44	375	1,217
27							
28	0	+					
29							
30	0	55	52	159	+	544	810
31							
6/01							
02	0	18	6	0	0	0	24

Table 4. Aerial observations of herring spawnings in the Togiak area of Bristol Bay, 1978-1980. 1/

Date	1978		1979		1980	
	No. 2/	Miles 3/	No. 2/	Miles 3/	No. 2/	Miles 3/
4/15					0	0
4/28					0	0
4/29						
4/30			2	2.5	0	0
5/01	1	0.4				
5/02			21	8.3	11	4.0
5/03	1	0.4	14	5.0	8	3.0
5/04			8	3.1		
5/05			1	1.3	0	0
5/06					3	0.9
5/07			3	0.6	3	1.2
5/08	2	1.8			1	0.2
5/09			2	0.4		
5/10			0	0		
5/11	9	7.7			0	0
5/12	3	1.5	0	0	0	0
5/13	12	8.6			0	0
5/14	11	5.6	0	0	2	2.3
5/15					6	4.0
5/16			0	0	4	1.2
5/17			0	0		
5/18	11	4.2				
5/19	3	2.5			1	0.3
5/20					4	0.9
5/21			0	0		
5/22					2	0.5
5/23						
5/24						
5/25	8	4.2				
5/26	2	2.2	1	0.7		
5/27					3	0.3
5/28	0	0				
5/29					8	1.6
5/30	6	1.6				
5/31					2	0.8
6/01						
6/02	1	0.5				
6/03						
6/04						
6/05						
6/06						
6/07					6	3.1
Total	70	41.2	52	21.9	64	23.1

1/ Survey area covers Nushagak Peninsula to Togiak Bay.
2/ Number of individual herring spawnings.
3/ Linear miles of spawn.

Table 5. Conversion estimates; metric tons of fish per 50^2 meters of surface area, Togiak herring grounds, 1978-1980.

Date	Observer	Est. of tons /50^2m	School size in feet	Weight of catch in tons	Actual or est. weight of catch	Fish condition	Location of set	Water depth in feet
5/13/78	Nelson	6.7	1/	1/	Estimated	1/	Nunavachak Bay	1/
5/18/78	Nelson	11.0	80 x 60	110	Estimated	2/	Nunavachak Bay	1/
5/04/79	Randall	2.4	40 dia.	5.6	Actual	Ripe	Ungalithluk Bay	20
5/15/80	Barton/Nelson	1.22	60 x 40	6	Actual	Ripe	Ungalithluk Bay	10
5/15/80	Barton/Nelson	1.63	40 x 30	4	Estimated	Spawn-outs	Ungalithluk Bay	25
5/16/80	Barton/Nelson	1.14 2/	220 x 50	21	Actual	Spawn-outs	Nunavachak Bay	15
5/16/80	Barton/Nelson	1.17	65 x 20	3	Estimated	Fish lost	1 Mile West Ungalithluk Pt.	16
5/20/80	Barton/Nelson	2.99	70 x 70	30	Estimated	Ripe	East of Eagle Bay	20
5/20/80	Barton/Nelson	2.60	150 x 75	60	Estimated	Fish lost	Eagle Bay	20

1/ Incomplete data.
2/ Average of 2 observers estimates.

Table 6. Relative abundance of fish in the Togiak District used to calculate 1980 herring biomass.

Date	Nushagak	Kulukak	Nunavachak	Ungalikthluk	Togiak	Matogak	Total
May 6	4,321 1/	1,845 1/	61 1/	674 1/	4,730	505 1/	12,136
May 19	-	-	-	147	1,387	0	1,534
May 20	512	835	232 1/	-	-	-	1,579
	4,833	2,680	293	821	6,117	505	15,249

1/ Based on observations of Louis Barton; the remainder based on observations of Mike Nelson.

Table 7. Relative abundance of fish schools in the Security Cove District in 1978. 1979 and 1980 based on aerial survey data. Numbers represent counts of schools standardized by surface area.

DATE	1978	1979	1980
5/01			
5/02			2
5/03			
5/04			
5/05	0		23
5/06			
5/07			198
5/08		270	175
5/09			
5/10			
5/11			
5/12			
5/13	48		81
5/14		2,912	186
5/15			
5/16			1
5/17	0	135	
5/18			353
5/19			288
5/20	120		
5/21			
5/22			407
5/23			
5/24		288	1
5/25			
5/26			82
5/27			
5/28			
5/29	107		
5/30	246		
5/31			
6/01			
6/02			
6/03	28		
6/04			
6/05			
6/06			
6/07	0		47

Table 8. Relative abundance of fish schools in the Norton Sound District in 1980 based on aerial survey data. Numbers represent counts of schools standardized by surface area.

Date	Klikitarik	Unalakleet	Cape Denbigh	Norton Bay	Golovin	Bluff	Total
5/05							
5/06							
5/07							
5/08	12	35					47
5/09							
5/10							
5/11							
5/12							
5/13							
5/14							
5/15							
5/16							
5/17	55	0					55
5/18							
5/19		304	29				333
5/20							
5/21							
5/22							
5/23							
5/24							
5/25							
5/26							
5/27	232	6	7				245
5/28							
5/29	1,033	0	507				1,540
5/30							
5/31							
6/01							
6/02	83	0	0				83
6/03							
6/04	212						212
6/05							
6/06	20	0	441	242	43	0	746
6/07		0	0	288	2	0	290
6/15						0	0
6/26		0	0	8	17	67	92

Table 9. Relative abundance of fish schools in the Norton Sound District in 1979 based on aerial survey data. Numbers represent counts of schools standardized by surface area.

Date	Klikitarik	Unalakleet	Cape Denbigh	Norton Bay	Golovin	Bluff	Total
5/15	85	9					94
5/16							
5/17							
5/18							
5/19							
5/20							
5/21	797	6	146				949
5/22							
5/23		6					6
5/24			48				48
5/25							
5/26							
5/27							
5/28		67	627	2	0	26	825
5/29							
5/30		92	212				304
5/31							
6/01							
6/02			7	62	34	103	234
6/03							
6/04							
6/05							
6/06							
6/07							
6/08							
6/09			10	49	27	248	334
6/10							

Table 10. Relative abundance of fish schools in the inshore waters of the eastern Bering Sea, 1978-1980.

DISTRICTS	1978 RAI	1979 RAI	1980 RAI
Togiak	43,050	137,630	15,249
Security Cove	246	2,912	435
Goodnews Bay	241	3,729	N/A
Nelson Island	1,079	N/A	N/A
Cape Romanzof	539	N/A	N/A
Norton Sound	1,277	1,860	2,242

Table 11. Estimates of inshore herring biomass (m.t.) in the Bering Sea, 1980.

Togiak District	62,300
Security Cove	1.100
Goodnews Bay	1,100
Nelson Island	5,400
Cape Romanzof	2,700
Norton Sound	7,600
	80,200

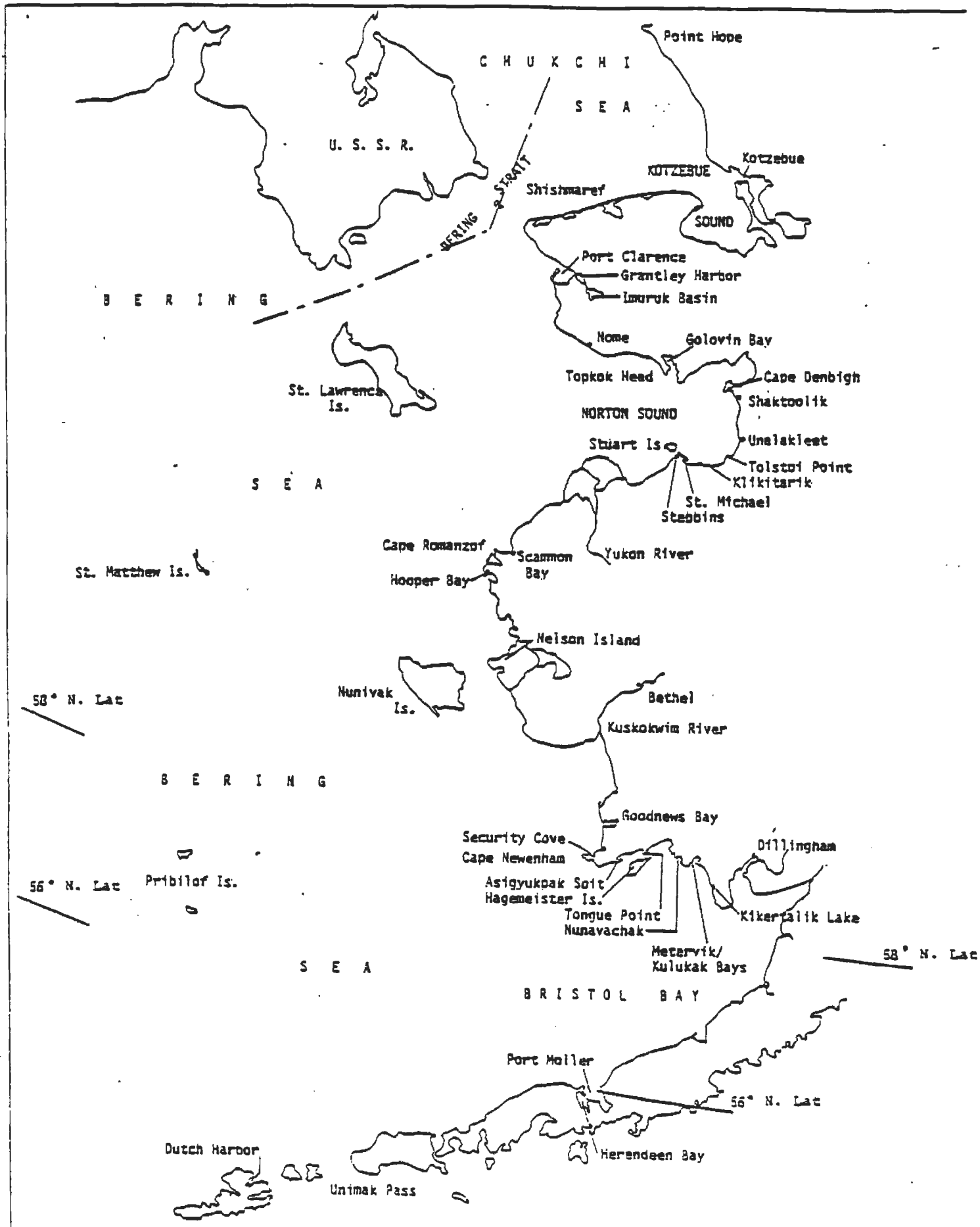

Figure 1. Eastern Bering Sea study area.

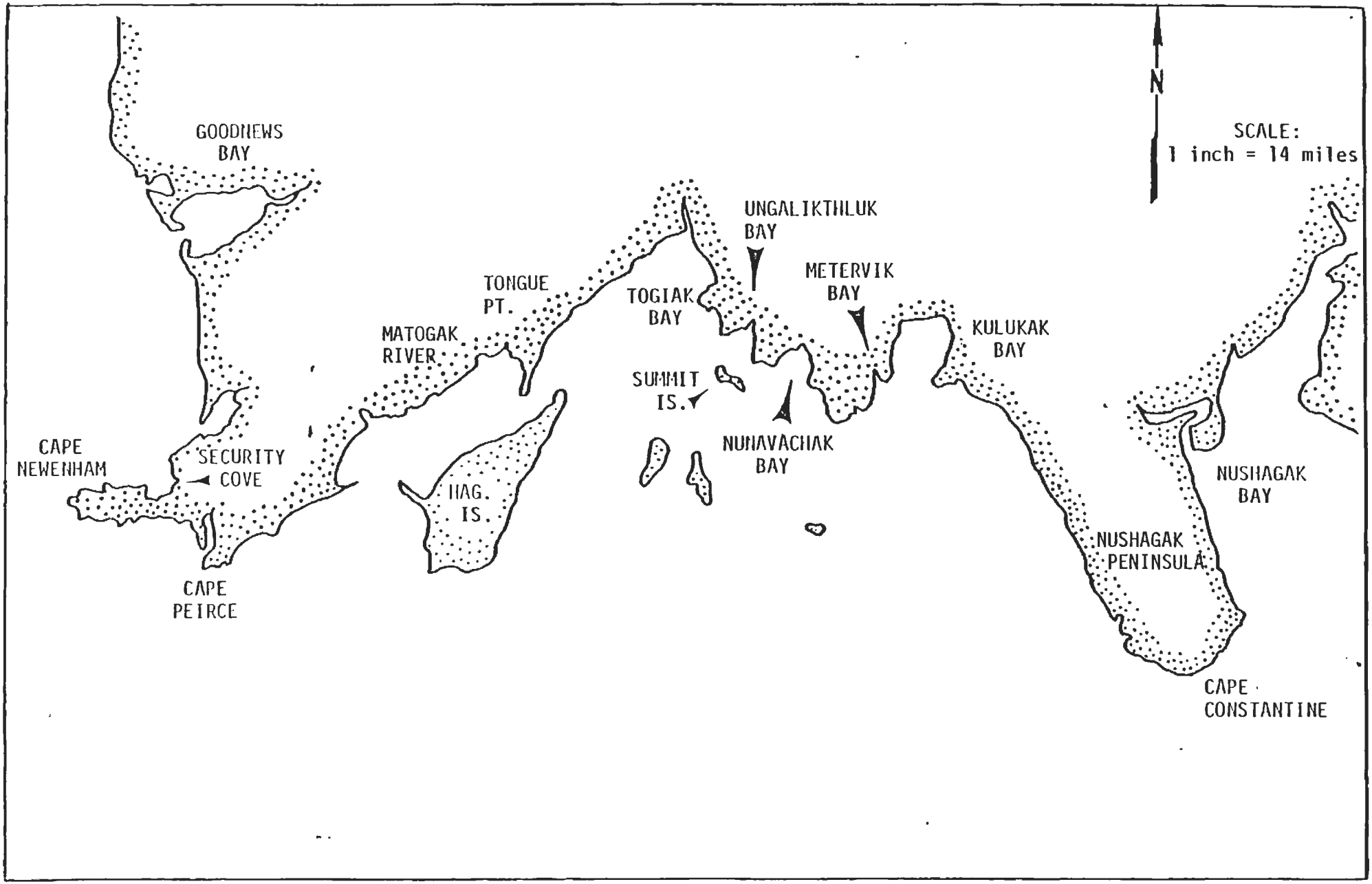

Figure 2. Map of the Togiak District of Bristol Bay showing aerial survey index areas.

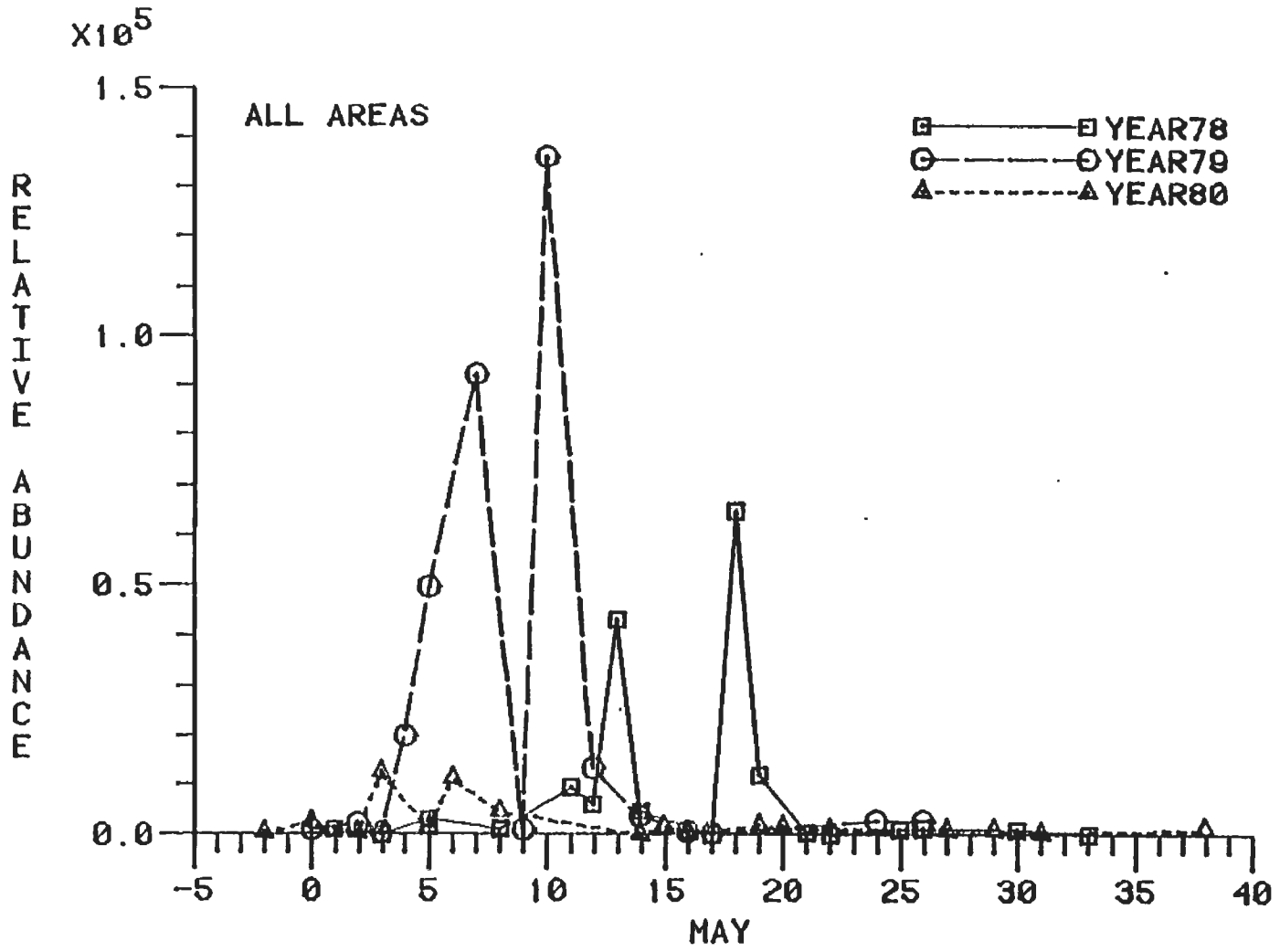

Figure 3. Relative abundance of fish schools in the Togiak District of Bristol Bay in 1978-80 based on aerial survey data.